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A New Species of *Kalophrynus* with a Unique Male Humeral Spine from Peninsular Malaysia (Amphibia, Anura, Microhylidae)

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A new microhylid, *Kalophrynus yongi*, is described from the Cameron Highlands of Peninsular Malaysia. Morphologically, the new species differs from all known congeners by having a very stout forelimb with a humeral spine in males. Acoustically, it resembles *K. baluensis* and *K. heterochirus* and sharply differs from *K. interlineatus*, *K. pleurostigma*, *K. palmatissimus*, and *K. nubicola*.

Key words: *Kalophrynus*, new species, humeral spine, Southeast Asia, tadpole, taxonomy

INTRODUCTION

The genus *Kalophrynus* Tschudi, 1838 is indigenous from Southern China to Java, the Philippines, and Assam, India, and includes 14 or 15 species of small litter frogs (Das and Haas, 2003; Ohler and Grosjean, 2005; Frost, 2009). It has usually been placed in the subfamily Microhylinae Mivart, 1869 (e.g., Parker, 1934), but its phylogenetic relationships with the other microhylid genera are unclear (Frost et al., 2006) and it is now considered to represent a distinct subfamily, Kalophryninae (Frost, 2009). Three species in this genus (*K. pleurostigma* Tschudi, 1838; *K. robinsoni* Smith, 1922; and *K. palmatissimus* Kiew, 1984) have been recorded from Peninsular Malaysia (Berry, 1975; Kiew, 1984; Das and Haas, 2003). The known localities for these species on the Peninsula are usually at relatively low elevations, and the known highest record was 1006 m a.s.l. for *K. robinsoni* (Parker, 1934; Dring, 1979).

During my field trips to Peninsular Malaysia, I collected specimens of a *Kalophrynus* species from the top of the Cameron Highlands, Pahang, nearly 2000 m in altitude. Herpetological surveys in the regions around the Cameron Highlands have a long history (Smedley, 1931), but recent discoveries of new species of the ranid genus *Hylarana* Tschudi, 1838 (Leong and Lim, 2003) and megophryid genus *Leptolalax* Dubois, 1980 (Matsui et al., 2009) from there suggest the inadequacy of herpetological inventories in this montane region, like the situation for the lower regions of Peninsular Malaysia, where many new species have recently been discovered (cf. Grimer and Aun, 2008).

The *Kalophrynus* from the Cameron Highlands is morphologically unique and clearly differs from all the known species of the genus, and is described herein as a new species.

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MATERIALS AND METHODS

I made frog surveys around the top of Gunung (Mt.) Brinchang, Cameron Highlands. I recorded frog calls in the field using a cassette tape recorder (Sony TC-D5) with an external microphone (Sony ECM-23) and a digital recorder (Zoom H2). At the time of recording, I measured temperature with a quick-recording thermistor thermometer (Takara A 600). Calls recorded were analyzed with the SoundEdit 2 and SoundEdit Pro (MacroMind-Paracom, Inc) software packages on a Macintosh computer, as described elsewhere (Matsui, 1997). Tissue was taken from both post-metamorphic and larval specimens for subsequent biochemical analyses. Comparison of partial mt-DNA sequences with those from several congeners established the validity of assigning metamorphs to larvae, and their distinct specific status (Matsui, unpublished data).

Post-metamorphic specimens were fixed in 10% formalin, preserved in 70% ethanol, and stored at the Graduate School of Human and Environmental Studies, Kyoto University (KUHE) and Herpetological Collection at Universiti Kebangsaan Malaysia (UKMHC). Twenty body measurements were taken mainly following Matsui (1984): 1) snout-vent length (SVL); 2) head length (HL); 3) snout length (SL); 4) snout-nostril length (S-NL); 5) nostril-eye distance (N-EL); 6) eye length (EL, including eyelid); 7) tympanum-eye length (T-EL); 8) tympanum diameter (TD); 9) head width (HW); 10) internarial distance (IND); 11) interorbital distance (IOD); 12) upper eyelid width (UEW); 13) lower arm and hand length (LAL), from elbow to tip of third finger; 14) forelimb length (FLL); 15) tibia length (TL); 16) foot length (FL); 17) hindlimb length (HLL); 18) inner metatarsal tubercle length (IMTL); 19) first toe length (1TL), from distal end of inner metatarsal tubercle to tip of first toe; and 20) outer metatarsal tubercle length (OMTL). I made all measurements to the nearest 0.1 mm with dial calipers under a binocular dissecting microscope. I followed the system proposed by Savage (1975) for the description of toe-webbing states. Radiographs were prepared and minor dissections were made to examine the humeral spine.

For larvae fixed and preserved in 5% formalin, I took the following 13 measurements to the nearest 0.01 mm using a binocular dissecting microscope equipped with a micrometer: 1) total length (TOTL); 2) head-body length (HBL); 3) maximum head-body width (HBW); 4) body depth; 5) eye-snout distance; 6) eyeball diameter; 7) internarial distance; 8) interorbital distance; 9) tail length; 10) maximum tail depth; 11) maximum tail muscle depth; 12) maximum dorsal fin depth; and 13) maximum ventral fin depth. Measurements

were made mainly following Inger (1985), and staging followed Gosner's (1960) Table.

For comparisons, I examined specimens of *Kalophrynus* stored at KUHE; The Natural History Museum, London (BM); Museo Civico di Storia Naturale, Genova (MSNG); and Forschungsinstitut und Naturmuseum Senckenberg, Frankfurt am Main (SMF).

SYSTEMATICS

Kalophrynus yongi **sp. nov.**
(Fig. 1)

Diagnosis

A medium-sized species of *Kalophrynus*, adult males 28.8–31.0 mm SVL (mean=30.3, n=3); third toe longer than fifth; projection of fourth finger from palm as long as terminal phalanx of third finger; one or two tubercles under fourth finger; a gland above upper arm insertion; no light lateral stripe; distinct inguinal dark spot; sharp white asperities on nuptial pads; forelimb very stout, with a strongly developed humeral spine in males.

Etymology

The specific name is dedicated to Dr. Yong Hoi-Sen, Emeritus Professor of the University of Malaya, for his great contributions to Malaysian zoology.

Holotype

KUHE 15531, an adult male from near the top of Gunung Brinchang, 04°51'N, 101°38'E, 1954 m a.s.l., Cameron Highlands, Pahang, Peninsular Malaysia, collected by Kunio Araya, Masafumi Matsui, and Tsutomu Hikida on 8 January 1993.

Paratypes

UKMHC 00566, an adult male, locality and collectors as for the holotype, collected 9 January 1993; KUHE 52446, an adult male from a trail near the type locality (04°52'N, 101°38'E, 1991 m a.s.l.), collected 11 August 2008 by Amir Hamidy, Daicus M. Belabut, Masafumi Matsui, and Kanto Nishikawa.

Referred specimens

KUHE, unnumbered: a batch of eggs and three tadpoles, locality and collectors as for the holotype; three tadpoles, from a trail near the type locality, collected 11 August 2008 by Masafumi Matsui, Amir Hamidy, Daicus M. Belabut, and Kanto Nishikawa.

Description of holotype (measurements in mm)

SVL 31.0; habitus stocky, body widest at sacrum; head triangular, wider (10.1) than long (9.0); snout obtusely pointed, truncate in profile, projecting slightly beyond lower jaw; eye moderate, longer (4.0) than snout (3.6); canthus rostralis distinct, straight; lore vertical, slightly concave; nostril dorsolateral, below canthus rostralis, slightly closer to tip of snout (1.4) than to eye (1.6); interorbital distance (3.5) wider than internarial distance (2.4), the latter wider than upper eyelid (2.2); pineal spot absent; tympanum distinct, diameter (2.7) more than half that of eye, and separated from eye by one-ninth of tympanic diameter (0.9); upper jaw edentate; tongue only slightly notched, without papillae; a crenulated ridge of skin on palate anterior to pharynx, preceded by a shorter, similarly strongly notched one just posterior to level of eye; a median, subgular vocal sac; small vocal openings posterior to rictus.

Forelimb long (20.8) and very stout; fingers thick, basally slightly webbed; tips rounded, not dilated; fourth finger slightly shorter than first, latter shorter than second; portion of fourth finger projecting from palm (1.2) subequal to terminal phalanx of third finger (1.1); fleshy outer palmar

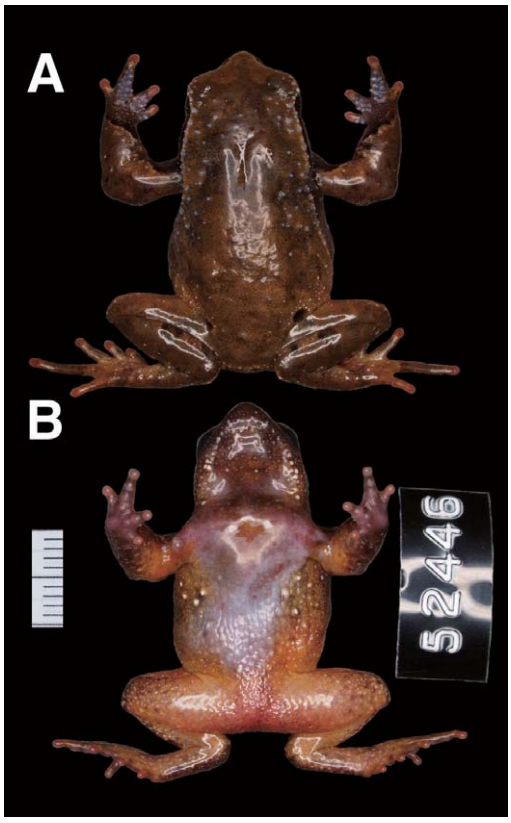

Fig. 1. **(A)** Dorsal and **(B)** ventral views of a paratype of *Kalophrynus yongi* (male, KUHE 52446). Scale bar, 10 mm.

Fig. 2. **(A)** Dorsal, **(B)** lateral, and **(C)** ventral views of a larva of *Kalophrynus yongi* (Stage 32, total length=25.1 mm). Scale bar, 5 mm.

tubercle, inner one indistinct, subarticular tubercles rounded, numbering one on first and fourth fingers, two on second finger, three on third finger (Fig. 3A); humeral spine short, shallowly curved, not hidden below the musculature of the forearm and moderately protruding (Fig. 4).

Hindlimb moderately long (44.7); tibia not long (12.9), heels not overlapping when limbs are held at right angles to body; tibiotarsal articulation of adpressed limb reaching to the point slightly posterior to rear angle of eye; foot (13.1) subequal to tibia; toe tips rounded; third toe longer than fifth; webbing poorly developed (Fig. 3B), formula: I 2–2+ II 2–3+ III 3–4+ IV 4–2 V; subarticular tubercles prominent, rounded, numbering one on first and second toes, two on third and fifth toes, and three on fourth toe; inner metatarsal tubercle rounded, length (1.4) more than half of first toe (2.5); outer metatarsal tubercle rounded but obscure, smaller (0.6) than inner one.

Skin above very finely granular with conical tubercles scattered dorsolaterally from upper eyelid to middle of body; a gland on side of head behind tympanum, delimited by a sinuous groove from eye above and behind tympanum to axilla, and curving over insertion of arm; side of body scattered with minute tubercles; chin, abdomen, and inner side of thighs with large, flattened glandules; few large tubercles scattered laterally on abdomen; skin of gular region not modified.; base of upper arm ventrally elevated at the position of humeral spine; inner and outer margins of fourth finger without skin fringes; nuptial pads with prominent excrescences in the form of comb-like rows of large, conical tubercles on dorsal surfaces of fingers; 10 or 12 on third finger, eight or 12 on second, and two on first.

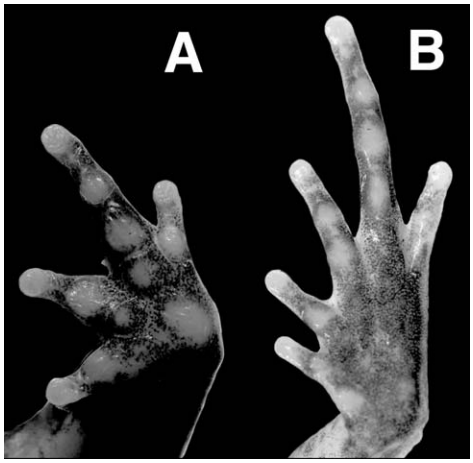

Fig. 3. Ventral views of **(A)** hand and **(B)** foot of the holotype of *Kalophrynus yongi* (male, KUHE 15531). Not to scale.

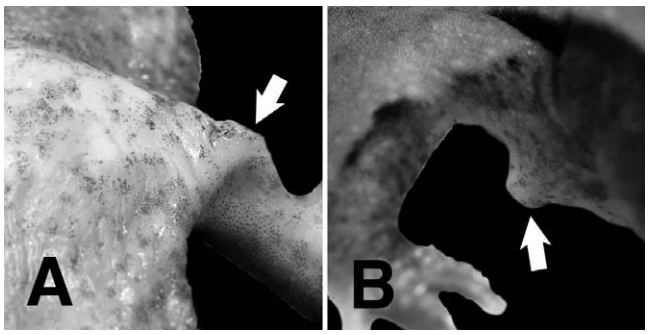

Fig. 4. **(A)** Ventral and **(B)** anterolateral views of the holotype of *Kalophrynus yongi* (male, KUHE 15531), showing the protruding humeral spine (arrows). Not to scale.

Color

In life, ground color of dorsum highly changeable from light orange brown to dark chocolate brown, with obscure dark markings, comprising a stripe commencing from tip of snout, interorbital bar, shoulder chevron, and transverse body bars, all irregular in outline and fused with each other; sides of head and shoulder dark brown, fused with a darker line along side, from posterior corner of eye, across flank, to front of groin, and forming a boundary between lighter dorsum and darker flank; tibia dorsally with an obscure dark bar; inner sides of arms marked with dark brown; ventrum dirty cream, dusted with brown on throat and scattered with black pigmentation on limbs; conical tubercles on nuptial pad, dorsolateral tubercles, minute tubercles on flank, and large tubercles on sides of abdomen white; inguinal spot black not bordered with light marking; upper and lower halves of iris golden with black pigmentation. In preservative, color and pattern have generally faded but not obviously changed.

Variation

Individuals of the type series are generally similar in morphology. In one individual, tibiotarsal articulation of adpressed limb reaches only to rear angle of tympanum, and there are two subarticular tubercles on fourth finger.

Eggs and tadpoles

The diameter of five eggs at St. (stage of Gosner, 1960) 13 (neural plate formed) from the type locality ranged from 1.88–2.14 (mean±2SE=1.99±0.14) mm. The animal pole was grey and the vegetal pole was cream in color.

Three tadpoles of St. 25 (TOTL=15.4 mm, HBL=3.8 mm), 30 (22.8 mm, 6.0 mm), and 32 (25.1 mm, 7.4 mm; Fig. 2) from near the type locality were closely examined (Table 2). Head-body somewhat elongate, slightly flattened above and below, HBW maximum at level of spiracle 53–55% (median=55%) of HBL; depth 36–43% (median=41%) of HBW; snout truncate; eyes lateral, visible only from above, eyeball 10–11% (median=10%) of HBL; interorbital wide, 285–350% (median=318%) of eye diameter; eye-snout distance 25–31% (median=27%) of HBL; nostrils dorsal, but not opened in St. 25 larvae, rim not raised, midway between eye and tip of snout; internarial 43–46% (median=45%) of interorbital.

Oral disk terminal and directed anteroventrally; width about 24% of HBW; lower lip not expanded; oral papillae, labial teeth and jaw sheaths entirely absent.

Spiracle median, without free flap, opening three-fourths of distance from tip of snout to end of body; vent median, in form of long tube directed obliquely backward, small opening at edge of ventral fin; gut in form of two, thick loops visible ventrally.

Tail long and lanceolate, tapering along posterior three-fifths to bluntly rounded tip without terminal filament; tail

Table 1. Measurements of 20 characters in *Kalophrynus yongi*. SVL (mean±1SD, in millimeters) and medians of ratios (R) of other characters to SVL, followed by ranges in parenthesis. See Methods for character abbreviations.

SVL	RHL	RHW	RIND	RIOD	RUEW	RSL
30.3+1.3	29.0	32.6	7.1	11.3	7.6	11.5
(28.8–31.0)	(28.8–29.4)	(31.9–32.6)	(6.9–7.7)	(10.6–11.8)	(7.1–7.7)	(11.0–11.6)
RS-NL	REL	RN-EL	RTD	RT-EL	RLAL	RFLL
4.5	13.5	5.6	8.7	0.6	48.1	64.6
(4.2–4.5)	(12.9–13.9)	(5.2–5.8)	(8.7–8.7)	(0.3–1.0)	(47.9–49.4)	(64.5–67.1)
RTL	RFL	RHLL	RIMTL	R1TOEL	ROMTL	
41.6	42.3	144.2	4.7	7.3	2.4	
(38.1–43.1)	(37.1–42.7)	(134.5–147.6)	(4.5–4.8)	(6.5–8.1)	(1.9–2.9)	

length 240–305% (median=280%) of HBL, maximum depth 12–20% (median=17%) of length; caudal muscle moderately strong, tapering gradually; fins with sub-parallel margins, not deeper than tail muscle; dorsal fin originating at end of head-body, with a straight margin, not much deeper than ventral fin, latter about equal to depth of caudal muscle near end of tail.

Color in life brownish black on dorsum and laterally, without marking; venter grey and belly transluscent.

Range

Known only from the type locality, around the top of Gunung Brinchang, Cameron Highlands, Pahang, Peninsular Malaysia.

Natural history

On Gunung Brinchang, the breeding season of *K. yongi* seems to be long, including mid August and early January. Eggs and larvae were found in early January in a large cup of the pitcher plant *Nepenthes macfarlanei* Hemsl., 1905 in dense moss forests on mountain slopes. Eggs were attached to the inner wall of the cup singularly or in small clumps, above the level of water. Larvae hid themselves among debris at the bottom of the cup. Three tadpoles were collected, but I failed to fix them sufficiently for measurement. Two of them were at St. 25, though their body size greatly differed. The remaining one was already at St. 36. The tadpoles described above were found in a hole in a stump, filled with rainwater, on partially logged slopes in mid August. They still retained much yolk (Fig. 2C) and seemed not to be feeding on other material. Males were found calling in a loose chorus at night both in January and August. Calling males hid themselves near breeding sites but were very difficult to locate. One individual vomited spiders, a grasshopper, and a weevil in the container. The only associated anuran species observed was larval *Microhyla annectens* Boulenger, 1900 which was found in a dumped tire filled with rainwater.

Call characteristics

Calls (Fig. 5) were recorded at an air temperature of 13.1–14.5°C. The call was a soft 'ting', and emitted intermittently with a note gap of 3.3–7.0 s (mean±SD=4.41 s±1.08, n=12). It consisted of a short, unpulsed note and lasted about 134–288 ms (mean±SD=174.7 ms±37.5, n=21). The dominant frequency was the fundamental, and slight frequency modulation was present. The initial frequency of 1300–1600 hz (mean±SD=1532 hz±80, n=20) quickly rose to 1300–1800 hz (mean±SD=1566±363 hz, n=19), and ended at about 1350–1650 hz (mean±SD=1 531 hz±76, n=20). At least seven clear harmonics were evident.

Comparisons

In males, *K. yongi*, with a SVL of 28.8–31.0 mm (mean=30.3 mm), is larger than *K. robinsoni* Smith, 1922 (16.8 mm [my measurement of the holotype BM 1947.2.11.51]); *K. nubicola* Dring, 1984 (14.4–24.4 mm); *K. menglienicus* Yang and Su, 1980 (19.8–23.4 mm, mean= 21.2 mm); *K. bunguranus* (Günther, 1895) (20.7–22.8 mm, mean=21.8 mm [my measurement of the syntypes BM 1974.4061, 4065, 4066]); *K. subterrestris* Inger, 1966 (21.0–23.4 mm, mean=22.6 mm); *K. heterochirus* Boulenger, 1900 (24.1–27.2 mm, mean=26.3 mm); *K. eok* Das and Haas, 2003 (26.3 mm); and *K. punctatus* Peters, 1871 (28.3 mm [my measurement of the holotype MSNG 29130]). By contrast, the remaining species are larger than *K. yongi* in male body size: *K. minusculus* Iskandar, 1998 (32.2 mm [my measurement of SMF 53814]); *K. palmatissimus* (31.2–38.8 mm, mean=34.5 mm); *K. orangensis* Dutta, Ahmed, and Das, 2000 (35–38 mm); *K. intermedius* Inger, 1966 (37.9–40.5 mm, mean=39.2 mm); *K. baluensis* Kiew, 1984 (34.8–39.0 mm); *K. pleurostigma* (35.0–50.4 mm, mean=42.2 mm); and *K. interlineatus* Blyth, 1855 (37.4–47.7 mm) (data from Das and Haas, 2003; Dring, 1979, 1984; Inger, 1954, 1966; Iskandar, 1998; Kiew, 1984a, b; Matsui, 1979, unpublished; Yang and Su, 1980).

Most remarkably, *K. yongi* differs from all the other *Kalophrynus* species in having strongly developed terminal ridges on humerus, and related skin modification. In addition, it differs from the other *Kalophrynus* species in the following characteristics (data from Das and Haas, 2003; Dring, 1984; Inger, 1966; Kiew, 1984a,b; Matsui et al., 1996, unpublished; Mertens, 1957; Yang and Su, 1980): (1) subarticular tubercles of fingers and toes distinct (indistinct or absent in *K. nubicola*); (2) fifth toe not projecting as far as third toe (projecting as far as or farther than third in *K. punctatus*); (3) tympanum distinct and toe web present (tympanum concealed and no toe web in *K. menglienicus*); (4)

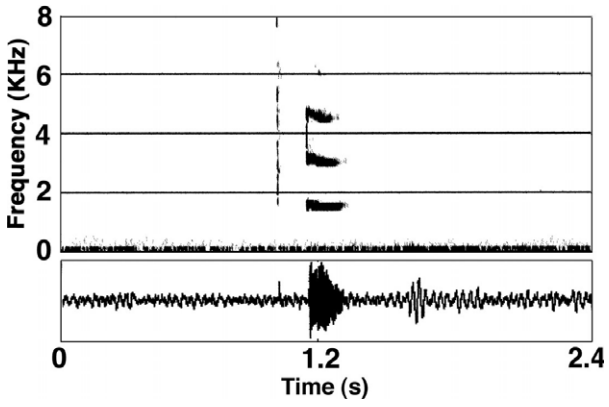

Fig. 5. Sonagram of an advertisement call of *Kalophrynus yongi*.

second finger with two subarticular tubercles (single subarticular tubercle in *K. eok*); (5) fifth toe with two subarticular tubercles (no subarticular tubercle in *K. subterrestris* and *K. intermedius*),; (6) portion of fourth finger projecting from palm as long as terminal phalanx of third finger (longer than terminal phalanx of third finger in *K. interlineatus*, *K. minusculus, K. palmatissimus*, *K. pleurostigma*, and *K. orangensis*); (7) no light stripe or line on snout or side (a light stripe or line along canthus rostralis, extending back along side almost to groin in *K. bunguranus* [Leong et al., 2003] and *K. heterochirus*); and (8) distinct spines on male nuptial pad (without spines in *K. baluensis*). In addition, *K. palmatissimus* has well-developed webbing on fourth toe to beyond median subarticular tubercle, which sharply contrasts with the poorly developed webbing in *K. yongi*.

In the larvae, *K. yongi* differs from *K. pleurostigma* from Singapore reported by Leong and Chou (1999) (=smaller form of *K. p. pleurostigma* from Peninsular Malaysia of Berry, 1972) in having larger body size (7.4 mm in HBL at St. 32 vs. to 4.3 mm at St. 43 in *K. pleurostigma*), an elongate head-body (vs. subspherical in *K. pleurostigma*) with dorsolateral eyes not visible from below (vs. lateral eyes visible from above and below in *K. pleurostigma*), and tail fins lower than tail muscle and ventral and dorsal fins similar in depth (vs. fins deeper than tail muscle after proximal third and ventral twice depth of dorsal in anterior quarter of tail in *K. pleurostigma*). Larval *K. yongi* also differs from Berry's (1972) larger form of *K. p. pleurostigma* from Peninsular Malaysia in having larger body size (to 4.5 mm at St. 36 in the larger form), and in having a rounded tail and terminal mouth (vs. an acutely pointed tail and a ventrolateral mouth in the larger form). Kiew (1984a) described larval *K. palmatissimus* from Malaysia as having the head-body 8 mm in length at St. 38 and rounded ventrally, eye visible from below, slightly extended lips, spiracle with a free flap of skin, longitudinal grooves on ventral surface of abdomen, tail fins as high as muscle at middle of tail, filamentous tail tip, and weak caudal muscle, all of which differ from the characteristics of *K. yongi*.

Calls have been analyzed for four species of *Kalophrynus* (*K. nubicola* from Borneo by Dring [1984]; *K. pleurostigma* from Borneo by Matsui et al. [1996]; *K. interlineatus* from Thailand by Matsui et al. [1996] and from Vietnam by Ohler and Grosjean [2005]; and *K. baluensis* from Borneo by Malkmus and Riede [1996]). Calls of *K. nubicola* described by Dring (1984) were expressed as 'gek' (type-one call) or 'gegger' (type-two call). Of these, type one is more similar to the call of *K. yongi* in duration. However, calls of *K. nubicola* were reported to be well pulsed, unlike the unpulsed calls of *K. yongi*. The call of *K. pleurostigma* is composed of successive notes (Matsui et al., 1996) and that of *K. interlineatus* is a long trill (Matsui et al., 1996; Ohler and Grosjean, 2005), unlike the short note in *K. yongi*. By contrast, the call of *K. baluensis* is similar to that of *K. yongi* to the human ear (Matsui, unpublished). The call characteristics of this species recorded at 19.0°C (Malkmus and Riede, 1996) are basically similar to those of *K. yongi*. However, the reported dominant frequency of *K. baluensis*, 2600 hz, is decidedly higher than that of *K. yongi* (mean=1531 hz), despite the former having larger body size than the latter (see above). The difference is not ascribed to different temperatures at the time of recording (13.1–14.5°C in *K. yongi*), either, and should be regarded as a specific one. Although not yet analyzed in detail, the call of *K. yongi* resembles that of *K. heterochirus* from Borneo, but sharply differs from that of *K. palmatissimus* from the Peninsula (Matsui, unpublished). The call of *K. palmatissimus* has been described as a soft "ko-ko-ko-ko" (Kiew, 1984), and is clearly very different from that of *K. yongi*.

DISCUSSION

Peninsular Malaysia forms a central geographical link between the faunas of Indochina and the Sunda Islands. Herpetological studies in this region have a long history (e.g., Boulenger, 1887, 1912a; Flower, 1896; Laidlaw, 1900; Butler, 1904; Smith, 1922, 1930), but for much of the latter half of the last century, studies were less frequent and sporadic (e.g., Grandison, 1972; Dring, 1979; Kiew, 1987) than in the eastern part (Sabah and Sarawak of Borneo) (e.g., Dring, 1984, 1987; Inger, 1956, 1964, 1966; Inger and Tang, 1996; Matsui, 1979, 1986).

Recent herpetofaunal surveys have greatly clarified the high amphibian diversity on the Peninsula (e.g., Leong et al., 2003; Grismer, 2006a,b, 2007; McLeod and Norhayati, 2007). Some species formerly treated as wide ranging were separated as distinct forms: *Hylarana banjarana* (Leong and Lim, 2003) from *H. signata* (Günther, 1872) (Leong and Lim, 2003); *Ansonia latirostra* Grismer, 2006 and *A. jeetsukumarani* Wood, Grismer, Norhayati and Juliana, 2008 from *A. malayana* Inger, 1960; *A latiffi* Wood, Grismer, Norhayati and Juliana, 2008 from *A. leptopus* (Günther, 1872) (Grismer, 2006b; Wood et al., 2008); and *Microhyla mantheyi* Das, Yaakob, and Sukumaran, 2007 from *M. borneensis* Parker, 1928 (Das et al., 2007).

Nevertheless, inventory studies remain insufficient and there are still many regions to be explored in detail. The discovery of *K. yongi* represents such a case, as did a new *Leptolalax* recently described from the same highlands (Matsui et al., 2009). Because the morphological and acoustic characteristics of *K. yongi* are so unique, it should not have been confused with congeneric species if herpetologists had ever encountered it. Even so, the possibility of the actual range of *K. yongi* extending to other mountain ranges on the Peninsula, such as Fraser's Hill or Gunong Tahan, is not precluded, although the range is probably not so wide because of limited habitat at higher elevations. Further field surveys are badly needed to understand the pattern of distribution and to infer the evolutionary history of the genus *Kalophrynus*.

Kalophrynus yongi is characterized by having a humeral spine in the male. This bony spine on the upper part of each forelimb is the ventrolateral extensions of the humeral crista ventralis (Noble, 1924; Ruiz-Carranza and Lynch, 1991). The spine has been reported in males of various frog lineages, e.g., in Centrolenidae Taylor, 1951 (*Centrolene* Jiménez de la Espada, 1872) (Cisneros-Heredia and Mcdiarmid, 2007); in Ceratophryidae Tschudi, 1838 (*Telmatobius* Wiegmann, 1834) (Parker, 1940; De la Riva, 1994; Lavilla and Ergueta, 1999); in Hylidae Rafinesque, 1815 (*Bokermannohyla* Faivovich, Haddad, Garcia, Frost, Campbell, and Wheeler, 2005 [Bokermann, 1964], *Ecnomiohyla* Faivovich, Haddad, Garcia, Frost, Campbell, and Wheeler, 2005 [Mendelson et al., 2008], and *Litoria* Tschudi, 1838 [Boulenger, 1912b; Zweifel, 1958; Faivovich et al., 2005]); and in Rhacophoridae Hoffman, 1932

(*Philautus* Gistel, 1848) (Kuramoto and Joshy, 2003). However, no spine has been reported in the genus *Kalophryus* or in the family Microhylidae Günther, 1858.

Cisneros-Heredia and Mcdiarmid (2007) recognized considerable variation in the degree of development of the humeral spine among species of *Centrolene*, and the nonprotruding spine found in *K. yongi* is poorly developed. Although Cisneros-Heredia and Mcdiarmid (2007) considered the spine to be a synapomorphy for *Centrolene*, not all species other genera of Centrolenidae have the spine. I regard the unique humeral spine in *K. yongi* as an apomorphic character state within the genus and an autapomorphy for the species. Although the humeral spine in male *K. yongi* is of unknown function, it may be advantageous for maintaining amplexus, as suggested by the massive forelimb and strongly developed nuptial spines, and field observations of the breeding behavior are necessary.

Members of *Kalophrynus* have been reported to breed in shallow, temporary rain pools, rain-filled road ruts, water-filled holes in logs, decaying bamboo internodes, burrows in stream banks, and pitcher plant cups (e.g., Inger, 1966; Leong and Chou, 1999). Although Inger (1966) assigned a nepenthiphillous larva from Borneo to *Kalophrynus*, the generic identification remained questionable. Lim and Ng (1991) first confirmed the use of pitcher plant cups for breeding sites in this genus, in *K. pleurostigma* from Singapore. As these authors suggested, nepenthiphilous habits of *Kalophrynus* would be an extension of the phytotelmic breeding preference, and large pitchers of *Nepenthes* should be an especially important breeding place for *K. yongi* on steep slopes at the tops of high mountains, where rainwater scarcely remains. Leong and Chou (1999) reported that *K. pleurostigma* in Singapore uses *Nepenthes ampullaria* Jack, 1835, whose cups are smaller than those of *N. macfarlanei* used by *K. yongi*, and this difference in the size of the breeding pot may be related to the difference in larval body size between the two species.

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